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POTENTIALS FOR NUMERICAL MODELS IN WATER MANAGEMENT

RECOMMENDATIONS FOR LOCAL WATER MANAGEMENT WITH STAKEHOLDER INVOLVEMENT

Möjligheter för numeriska modeller inom vattenförvaltning

Rekommendationer för lokal vattenförvaltning med aktörssamverkan

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Abstract

The outcomes from two Swedish IHP workshops on the use of numerical models in water management are presented. The workshops involved researchers and modellers from various parts of Europe and representatives from the Swedish water management sector. Recommendations of good practices in the use of models, with emphasis on local water management and stakeholder involvement are presented. Models abilities to extrapolate and interpolate information and synthesize existing knowledge, as well as their potential to facilitate decisions related to complex questions, where several environmental and economic goals are integrated, were highlighted. However, also challenges that need to be overcome were identified, including the need of increased effort to address transparency and more effort on communication between modellers and users of model results. Provision of ranges of uncertainty was called for, as well as a focus on identification of reasons behind the discrepancies rather than striving for a "best fit" between models and measurements. The need to promote success stories, where models are used for collaboration between stakeholders and authorities and where this work has resulted in implementation of measures were addressed. By doing this, the participants anticipated that politicians will invest more resources in the use of models in water management.

Key words – hydrological models, water management, stakeholder involvement, Swedish IHP

Sammanfattning

Resultaten från två svenska IHP workshops runt användningen av numeriska modeller inom vattenförvaltningen presenteras. Dessa workshops involverade forskare och modellerare från olika delar av Europa, samt representanter från svensk vattenförvaltningen. Rekommendationer med avseende på god praxis i användningen av numeriska modeller, med betoning på lokal vattenförvaltning och olika aktörers deltagande presenteras. Modellernas styrka när det gäller att extrapolera och interpolera resultat, samt dess förmåga att syntetisera tillgänglig kunskap lyftes fram, liksom deras möjligheter att ge underlag till beslut runt komplexa frågeställningar, där flera miljömässiga och ekonomiska mål måste integreras. Deltagarna identifierade även utmaningar som måste övervinnas. Dessa inkluderade bl.a. behovet av ökad fokus på transparens och kommunikation mellan modellerare och användare av resultaten. Deltagarna önskade tydliga presentationer av osäkerhetsintervall, samt fokus på identifiering av orsaker till skillnader snarare än en strävan efter en bästas överenstämmelse mellan modeller och mätningar. Behovet av att främja framgångshistorier, där modeller används för samverkan mellan aktörer och myndigheter och där detta arbete har resulterat i genomförandet av åtgärderna lyftes fram. Genom att göra detta, förväntade deltagarna att politikerna kommer att satsa mer resurser på användningen av modeller i vattenförvaltningen.

1 Introduction

The International Hydrological Programme (IHP) is an intergovernmental programme of the UN system devoted to water research, water resources management, and education and capacity building. Since its inception in 1975, IHP has evolved from a strictly scientific programme to one that is also management and policy-oriented, and takes into account social, economic and cultural dimensions while still retaining a solid scientific core. The ambition of the IHP VII phase is that results achieved are action oriented and policy relevant so that all of IHP's audiences, including governments, the scientific community and civil society, can benefit from them.

As a Swedish contribution to IHP, two workshops were arranged by the Swedish IHP committee in March and September 2011[1] aiming at bridging the gap between hydrological modellers and water management.

Hydrological models can provide information for many issues of scientific and societal relevance. The EC has aligned Europe in a common policy for water in the Water Framework Directive (WFD) for protection of inland surface waters, transitional waters, coastal waters and groundwater[2]. The nitrates directive forms an integral part of the WFD and is a key instrument in the protection of waters against agricultural pressures. Also a bathing water directive[3] is integrated into all other EU measures protecting the quality of all waters through the WFD. There are also specific directives for, e.g., management of flood risks[4], drinking water[5], and urban wastewater[6]. A policy review for water scarcity and droughts, which is part of the "Blue Print for Safeguarding European Waters" was adopted by the EC in 2012[7]. In addition, there is a link between freshwater directives and the Marine Strategy Framework Directive[8]. To make it possible to implement these directives, there is a need for the development and use of new and improved communication arenas and tools, providing water managers and stakeholders with platforms and interactively produced information to assist in dialogues and decisions on water management. Improved communication between modellers and users of model-based systems has the potential to act as the core engines in this process.

Measures to improve water status are expensive and require good decision-support that enables recognition of co-benefits when addressing several environmental and economic issues simultaneously, including the impact of climate change. The capability to model and make scenarios is an asset for planning on scales ranging from the local to the transnational. Water information on short and long term is also needed for planning of all kind of infrastructure and management of natural resources, e.g. agriculture, forestry and hydropower. Also here, cooperation between authorities, sector representatives and the hydrological scientific community is vital for development and application of decision-support systems that can address questions related to: "What if?" – including the possibility to address interlinked question from the perspective of different stakeholders. Hydrological models are key elements for such an integrated water management approach. However, all model results include uncertainties. These are caused by a combination of incorrectness or oversimplifications of how processes or impacts of measures are modelled, and of how well available data and other information reflects realities in the spatial and temporal scales for which results are generated. When models are used to assess possible implications from, e.g., climate change, uncertainties related to societal development, as well as of models performance during future (unknown) conditions is added. Improvements in access to information, as well as scientific and technical developments call for adaptive management, which is the rationale behind the possibilities of re-evaluation of management decisions and programs, in line with the 6-yrs cycle of the WFD[9].

The WFD has a strong focus on public participation. Through dialogues, e.g., within the framework of water councils, there is a possibility to ensure that models are used together with available local information and that suggested remedies used in modelling scenarios are developed in cooperation with those that will have to take action. The models can thus be used as a platform for dialogues between experts, authorities and affected actors. A prerequisite for this, however, is that it is clarified what that is expected to be reached through public participation and that there are incentives for various actors to contribute to water management.

The aim of this paper is to present and discuss the outcome of the two Swedish IHP workshops involving researchers and modellers from various parts of Europe and modellers and representatives from the Swedish water management sector. The specific objective is to identify recommendations for improving the use of numerical models in water management, with focus on the use of models as a platform for stakeholder involvement in water management.

2 The Workshops

The first of the two Swedish IHP workshops; "*Nutrient model comparison – research analysis*" was directed towards modellers, with the aim to increase the understanding of differences/similarities in model outputs between different concepts linked to model uncertainty. The workshop was held in Söderköping, Sweden 28–

Table 1. *Presentations in plenum at the workshop* "Water status and hydrological models – handling of uncertainties in water management*", Stockholm 15–16th September 2011.*

Name	Organisation	Title
Ulla Mörtberg, Andrew Quinn	Södertörn University	Local participation in water management
Lotta Andersson	SMHI	Use of models as a tool for dialogues in water management
Anna Jöborn	HaV	Adaptive water management under uncertainty
Björn Sjöberg	HaV	The WFD – how far have we reached in Europe and Sweden and the role of HaV linked to the WFD

30th March 2011. There were 19 participants, representing seven modelling groups (applied models shown in brackets): DHI, Denmark (Mike-Basin), Geissen University, Germany (Lacsam), Oxford University, UK, (INCA), SLU, Sweden (FyrisNP), SMHI, Sweden (HYPE and HBV-NP), UFZ, Germany (HYPE) and Gdansk University, Poland (SWAT). Three representatives from the Swedish IHP committee moderated the workshop. Before the workshop, the eight modelling teams had set up and run their models for the same river basin (the Söderköping river basin). The focus of the modelling was on riverine water and nutrient (nitrogen and phosphorous) transport, and the effect of nine nutrient reduction scenarios provided by the County Board responsible for water management in the river basin. The modellers based their model setup on databases for present conditions, as well as management scenarios. Databases and information on management scenarios was made available for downloading approximately a month before the workshop. During the workshop the results were compared to additional monitoring data, in order to make validation against data not used for calibration possible. This work results related to model uncertainty will be presented in a forthcoming paper.

The participants did also provide recommendations on how to communicate model results, model limitations and strengths in order to make models and model results useful and used in water management. Discussions were held in three groups, followed by a moderated plenary session. The conclusions from this part of the modellers workshop were presented during the second workshop directed towards the use of models in water management and are presented in this paper.

The second workshop "*Water status and hydrological models – handling of uncertainties in water management*" was held in Stockholm 15–16th September 2011. The aim of this workshop was to, based on a dialogue between Swedish water managers and modellers, increase the understanding of what is needed in order to maximize the value of models as a tool for implementation of the WFD. Similar to the first workshop, the attention was on models for water and nutrient transport in river basins. Main focuses were on how to communicate and deal with uncertainties, and use pros and cons in the use in models in adaptive water management linked to participatory processes.

Out of 50 participants there were ten representatives from universities, ten from county boards, seven from municipalities, four from NGO:s, four consultants, three from the Swedish Geological Survey (SGU), five from the Swedish Meteorological and Hydrological Institute, three from the Swedish Agency for Marine and Water Management (HaV), three from Water Authorities, and one from the Swedish Environmental Protection Board (NV). Three representatives from the Swedish IHP-committee participated as moderators of the workshop.

Some presentations in plenum were given, related to adaptive water management, and participatory processes (see table 1). Presentations were also given on the outputs from the first workshop. The main part of the workshop, however, consisted of group discussions with the participants divided in six groups. The group discussions were followed by presentations and discussions in plenum, addressing the following questions:

First round of discussions:

1. How are assessments related to nutrient status and action plans linked to water management carried out today in Swedish water management?
2. What is needed in order to increase the use of models?
3. What is your response on the presented recommendations that emanated from the first workshop with regard to good practices, including how to communicate models, model limitations and strengths?

Second round of discussions:

1. What can be reached through increased local participation in water management?
   – What are your experiences and visions?
   – What role can models play here?

2. What limits the use of models in water management?
   – Access to modelling systems (and modellers)?
   – Access to relevant information on the local scale?
3. Are flexible (web based) transparent tools that allows inclusion of local information with excellent visualizations of model assumptions (transparency) and results what we need?
   – Or is it something else?
   – Or are the models not needed?

A final discussion in plenum was held in order to identify the main messages from the workshop.

3 Recommendations from the modeller's workshop

This section is based on notes from the group and plenary discussions during the modeller's workshop that relate to recommendations on good practices to facilitate communication between modellers and water managers.

3.1 Arguments for why to use dynamic hydrological models

Arguments put forward were that all decision support is based on some degree of systematic structuring of data and knowledge. In some cases, based on a systematic organization of knowledge and previous experiences, the structuring is made "inside the head" of water managers. This can be complemented by the use of empirical models based on statistical correlations. However, it was expressed that access to dynamic hydrological/nutrient models provides an added value due to their ability to:

– efficiently organize complex data and process understanding, including feed-backs and other interlinkages
– make it possible to interpolate and extrapolate between observations to time series and geographical areas not covered by monitoring programmes
– assess the impact of single or combination of measures in management plans, with consideration to where measures are carried out

3.2 Models and monitoring

It was emphasised that the use of monitored observations for validation of models is important for model credibility. It was recommended to wisely combine available measurements and models, and to continuously update model setups against new observations. The importance to update models when new monitored data are made available was discussed both in connections to real-time forecasts and the 6-years cycle perspective of the WFD, related to status classifications.

Another recommendation was that when a model is used to reflect spatial variability, validation should not be limited to the outlet of the catchment. Spatially dense field campaign monitoring was recommended as a way to substantially increase confidence in the models ability to reflect spatial variability. It was also emphasised that there is a need for well-established communication channels between modellers and water managers in order to ensure that user's observations of local error in model results, as well as local monitoring is provided to modellers so that they can be used for improvements.

It was also emphasized that the use of models for interpolation between observations can add information compared to linear interpolation since it is possible to consider physical processes, linked to climate-related dynamics during and between measurements. This was seen as specifically valuable when extrapolating from monitored to ungauged basins.

3.3 Models for testing of consequences of various scenarios

The possibility to use models to carry out complex analyses of possible consequences of a combination of multiple choices of measures and climate variability were acknowledged by the participants. The advantage of not only being able to in general term address the impact of a single suggested measure, but to also be able to address the importance of where it is carried out and to assess the combined effect of various measures was emphasised.

3.4 Handling of uncertainties

It was agreed among participants that to ensure transparency it is important to provide uncertainty estimates. A recommendation put forward was to provide ranges (e.g. median, and selected percentiles), based on calculation with a set of different combinations of parameters, instead of only provide a single value. However, it was also recommended not to run models with unrealistic parameter value combinations since this will provide irrelevant information.

In line with the outcome from the model comparison, showing that result from different models in some cases deviated significantly, it was recommended to base decisions on outputs from several models. It was put forward that although different models not quantitatively give the same results, the robustness increase if the output from several models provides the same relative ranking of the impact of a set of suggested measures. Although the vision of the participants was a system where water managers had access to results from several models, the practical and economical limitations for implementation of such systems were, however, acknowledged.

Another discussion focused on that if poor model performance is due to lack of data (e.g. caused by wrong information on land use), calibration aiming to provide "best fits" with measurements might twist the outputs from the modelling system in a way that bias the results towards overestimation of the contribution of, e.g., nutrients from one source to compensate for underestimations from another source. A recommendation to cope with this dilemma was to not only strive towards "best fit" between modelled and monitored water and nutrient flow, but to also focus on identification of reasons behind the discrepancies. This includes assessments of the limitation of input data, representation of processes, but also representatively of the monitoring programme.

If a good fit is achieved from selecting parameters outside realistic ranges or manipulating data in a non-transparent way, the results are probably not very useful from a water management perspective. Decisions based on such modelling results might lead to unwise decisions when it comes to prioritization of measures, since the source apportionment is wrong.

The hydrological research community have been focusing to a large extent on the reduction of uncertainties, and less on the implications of understanding the nature of uncertainties (random, systematic, representatively, accuracy) on the decision making. The above recommendations can be referred to as "learning from uncertainty" (Juston, 2012), which involves both objective quantification and subjective evaluation known and unknown properties of the uncertainties.

3.5 Communication between modellers, water managers, and stakeholders

It was concluded that water managers in many, and maybe most cases not are modelling themselves, but use results available on the web or from consultant services. The recommendation was therefore that all steps in the modelling process should be communicated, including availability and selection of databases, model setups, and choices of scenarios, validation and uncertainties (including the possible causes to these uncertainties, c.f. section 3.4). Every step in the modelling process is recommended to be initiated with a dialogue. Otherwise there is a risk that the results not will be perceived as useful and comments like "you should have discussed this with us" can be expected. It was seen as specifically important to have a dialogue with clients not only on how to obtain results, but also on how to interpret them. Although this might be seen as tedious and time consuming, it was seen as a clear success factor in the provision of something useful from a water management perspective. By implementing such an approach, clients will feel they are owners of the process, not merely receivers of a ready-made product. This will also ensure a common responsibility for the quality of model-generated information. In addition to dialogue, it was also recommended that modellers provides training (about 2 days) to those that are going to apply model results, which was seen as a pre-requisite for fruitful dialogues and sound ways of using model results in water management.

4 Messages from the stakeholder's workshop

This section is based on the discussions during the group and plenary discussions. The four questions (see Section 2 above) from the two rounds of group discussion in the six groups, as well as the plenary session were, with permission from participants, recorded. After the workshop, the relevant parts from the recordings were transcribed and summarised for each of the six groups. This summary was the basis for the following section of this paper.

4.1 Tools presently used for status classification and impact assessments

Several county boards used the "indicative model", which is an expert judgement based on three steps: (i) simplified impact assessment, indicating water bodies with high anthropogenic impact or environmental problems; (ii) verification of the selection through monitoring and field observations; (iii) status classifications (Öhman and Johansson, 2009). The success of the method depends on available monitored data and on responsible water-managers knowledge and previous experiences. Access of (dynamic) model results was seen as an added value that could confirm their judgements. The limited use of dynamic models was usually due to lack of time and financing but also limited access of data in relevant temporal and spatial scales was mentioned as a constraint. In some cases modelled information on nutrient loads from PLC-5 (Sonesten, 2011) were used. This information is based on databases with a national coverage, which was seen as a constraint for use on geographical levels relevant for local water management decisions. The large-scale variability of nutrient loadings provided by PLC-5 was seen as only confirming what already is known. A few did also use models that had been setup locally. However, these models were generally not used for status classification.

The main rationale for introducing the use of dynamic models was seen in their potential as pedagogical tools for common understanding of the apportionment of sources to nutrient loads, and of the impact of various measures. Such understanding was seen as important in order to get acceptance for measures.

It was emphasised that it is problematic to classify a water body as not reaching "good status" when monitoring not is available. The public (i.e. those that will be responsible for carrying out measures) will react with frustration if information provided after the classification was made indicates that the classification was wrong. However, even with access to monitored data, classification was judged to be a difficult task since time series with only a few measurement might not be representative of dynamics caused by variations in water flow and between seasons. It was also seen as a constraint that the reference values used for classification not always reflected local realities. In this context, it was, e.g., questioned if it made sense that naturally eutrophic lakes had the same reference level as naturally oligotrophic lakes. There were also concerns about the static nature of the existing reference levels, since new research can lead to change of reference levels, as well as of recommendations of how to calculate them. Change of reference levels might have a significant impact on water management, with economical and practical implications for stakeholders. A scenario where many decisions eventually will have to be made by environmental courts after appeals by stakeholders, were seen as possible in the coming years.

4.2 Recommendations of how to increase the use of dynamic models

The use of (dynamic) models was expected to increase in the implementation of the new cycle of the WFD (2015–2021). However, it was assumed that not all authorities will have the capacity, neither in the form of skills, time allocation or budget, to set up and run models. Many will rely on model results provided from web-services or on consultancy services. As mentioned previously, this calls for transparency and dialogues. It was emphasised that dynamic models only is one of many tools for a water manager, and clear guidelines for when and how models can be a cost-efficient way to use available resources were called for.

It was emphasised that, especially on the local scale, water management need to be based on a combination of monitoring, models, local knowledge and expert judgement. To integrate these sources of information, it was seen as important to couple systems for retrieving data and information, including model-based results. Examples mentioned included coupling of model-based results and economic evaluations with the status classification information in the water authorities' database VISS (Water Information System for Sweden, http://www.viss.lansstyrelsen.se).

It was concluded that model-based results often are questioned by stakeholders. This was seen to partly be due to low transparency, where the modeller's time given and their skill to explain model concepts and outcomes in an understandable way were seen as limited.

A suggested way forward was to shift from a "top-down" approach, where only final results are presented, to a "bottom-up" approach. Water councils were seen as appropriate foras for interactive, model-based dialogues, where participants, e.g., assists in generating input data and suggest measures to be tested by the model.

There was a request for model-interfaces that make it possible for water managers to use models, without having to be modellers themselves. In was also emphasised that there is a need for a shift from the prevailing use of models linked to short-term project activities to making the use of models a part of the ordinary work.

Again, the issue of scale was raised, emphasising that modelling had to be relevant for the scale where it is to be used. It was, e.g., stated that nationally set up models, such as PLC-5, not should be used to issue permits with relevance to water management. According to the participants, use of local input data, calibration and verification against local monitoring programs was a prerequisite for the use of models in local water management. For modelling of impact of measures it was also stated that catchment models have to be complemented by process-based models on the field scale. The pedagogic challenge of presenting uncertainties was especially addressed, stating that it is not easy but has to be done, including clear information about the possible lack of local information to ensure that the model setup is representing real conditions.

Finally, when asked whose responsibility is was to ensure increased use of models in water management, the answer was that all that see the benefit have the responsibility to argue for and forward the message to politicians and others that can make funding available.

4.3 Responses on the presentation from the modeller's workshop

Ensemble modelling with a set of models was perceived as interesting and potentially increasing the confidence in model results, with the objection that it probably not will be economically feasible, at least not on the national scale. The use of "coarser glasses" and more models, instead of very detailed modelling with one model was suggested as one way forward. However, some mentioned the risk that using more models might provide limited new insight, since many models are based on the same assumptions. Being able to show that different models ranked the impact of measures in a similar way was seen to increase the robustness of the results, although some argued that if all models gave similar rankings of the efficiency of measures that might be a reason not to use several models. In general, the participants perceived that the larges sources of uncertainty were due to the input data, rather than to the selection of a specific model. A general recommendation was to clarify that model generated results rather should be seen as "good guesses" than as "hard facts".

The suggestion to provide model results in the form of a range (based on a set of different combinations of parameter values or a set of models) instead of just one single "curve" was responded to positively, with the addition that there is a need to be able to provide a clear and transparent definition of how the intervals were calculated and how they should be interpreted.

Another issue raised was that presentations of uncertainties should be adapted to what the results are to be used for. It is problematic to base decisions on model generated information if the range of model uncertainty is larger than the range between, e.g., prevailing and wanted nutrient loads or if the interval of model uncertainty spans over several classes in the WFD classification.

However, it was also argued that model uncertainties often not are the most critical uncertainty to handle in a water-management decision process. Identification of water-related problems and solutions are based on a large set of judgments and considerations. Consequently, it was suggested to broaden the focus on uncertainty, addressed during the modeller's workshop to also include other types of uncertainties linked to all steps in the decision-process.

4.4 Stakeholder involvement in water management

One of the aims of the workshop was to discuss the potentials of models as a platform for stakeholder involvement in water management. However, a first step for involvement is the existence of a willingness to participate. To succeed, the way models are used in the process of stakeholder involvement need to address "what's in it for me" from the various actors' perspectives.

4.4.1 Experiences and visions

By involving local actors in water management the local acceptance for the need for measures was expected to increase. All involved actors will have their own combination of economic and environmental agendas. By experience, participants agreed that it had in general been easier to engage land owners than industries, which was seen as a consequence of a strict focus on profit without incorporations of environmental evaluations.

The possibility to engage various actors in local water management was seen to be critically dependent on champions with skills for communication and trust building. Building confidence is a process that needs considerable amounts of time. Some participants stressed that it is important to carefully consider when and for what purposes local participation is vital, in order to use available economical and personal resources wisely. Such considerations will thus also need to be made when deciding on the use of models in participatory processes.

It was stated that local actors need to acknowledge the value of their water resources, which calls for use of models together with monitoring in order to obtain quantifiable valuations. However, this was recommended to be complemented with excursions, including walks along rivers, as a way to demonstrate local environmental values worth to protect.

It was also stated that many farmers have a negative image of authorities, including the county boards, which makes it difficult to communicate. In this context, the important role of water councils, which are independent from the county boards, was stressed. Water councils might therefore be an appropriate for a for model-assisted stakeholder dialogues. More funding to water councils were called for. In addition the need to extend information about the water councils to various actors, as well as to initiate more inclusive activities that attract participants (i.e. not only formal meetings) was mentioned. It was also noticed that many water councils are very active and do not solely depend on economic resources from authorities, but do also find funds from other sources, including regional and transnational development projects, in which modelling activities could be included.

Another issue raised was the importance of including other aspects than environment in the dialogues. Farmer's main concern is productivity, not the environment, which calls for win-win solutions for environment and production. Other focuses could, e.g., be tourism and fishing that indirectly depend on environmental status. Communication forums were seen to be valuable not only for vertical learning (top-down and bottom-up), but also for horizontal learning, e.g., between farmers. This could also be a way to provide groups of stakeholders with a common platform for negotiations with authorities.

It was also mentioned that different actors have different and sometimes conflicting incentives, goals and values related to water management. Factors such as flooding and eutrophication are dealt with by different legal frameworks that only consider one goal at the time. Due to this different parts of a county board might provide different messages. Consequently, involvements of local actor's would be facilitated if also the authorities and legal frameworks increased the potential for truly integrated water management. The importance of involving several aspects, in order to search for win-wins between various actors and to avoid unexpected downstream consequences, as well as to address both environmental and economic issues, will also need to be considered when deciding on how to include models in the dialogues. The discussion above does also demonstrate that models are one of many ingredients that feed the dialogues which need to be combined with other types of information in order to come to conclusions.

Finally, the need to involve politicians in stakeholder dialogues in order to ensure economic means for suggested actions was stressed.

4.4.2 Use of models in stakeholder dialogues

As indicated above, models were seen as a valuable pedagogic tool in the work of water councils, with emphasis on their ability to visualize sources and impacts of measures. Another suggestion was to use models in schools, e.g., as parts of "role plays", where the students can represent different stakeholders, including authorities.

By working interactively with models during meetings, the common perception of existence of and sources to eutrophication, as well as links between measures and reductions of nutrient loads can be obtained. Stakeholder's present contributions and possibilities for actions towards fulfilment of environmental and other goals can be visualized. Starting a dialogue with showing model projections of e.g., the impact of a set of measures might, be seen as provoking and it was recommended to instead start impartially and introduce models at a later stage. The project "Focus on nutrients" (http://www.greppa.nu/) was seen as a role model for engagement of actors in water management. It is a joint venture between the Swedish Board of Agriculture, the County Administration Boards, the Federation of Swedish Farmers and a number of companies in the farming business, that focus on increasing nutrient management efficiency by increasing awareness and knowledge.

It was challenged if the final decision related to river basin management plans should be the solely responsibility of authorities. If water councils not have any mandate, the use of models will only be pedagogical, which might limit the interest to participate in model-assisted dialogues.

It was stressed that for water-management, but also for research purposes, collection of relevant information and data, which also might include monitoring, benefits from local participation. The initiation of a denser network of weather stations, managed by locals to be used in modelling was suggested as one way to increase interest and at the same time improve the modelling. In this way the added value of more monitoring could also be assessed by field campaign modelling.

In summary, local participation in model-based water management projects was consequently seen as a prerequisite for success, where local participation, also from a scientific point of view, can give input to analyses of data and model results.

4.4.3 What limits the use of models?

Constructive use of models requires that they respond to real needs. The most critical limitation identified was the high degree of uncertainty when models are applied on the local scale. Use of models that have a low skill in predicting what they state they predict might discourage further use of models.

Another drawback was the perceived lack of continuity in the application of models in county boards and water authorities. This limits improvement, updating and use of local model setups, which also will limit the use of models in interaction with stakeholders, e.g., within water councils.

Finally, in order to be useful, it was seen as essential to ensure that the presentation of model results provides an "aha" experience, where participants obtain a feeling of that the results are relevant for their thinking. If that not is the case, the modelling is not cost-efficient. This was seen to require a high level of pedagogic effort. There is a need to avoid fragmented discussions of results that not feed into the dialogues. There was also an agreement that it rather is the model-assisted evolutionary group process that is important, not the exact values generated by the models.

5 Main messages from the workshops

Based on a final discussion in plenum the following main message was formulated by the participants:

- Dare to take decisions also when not all facts are there. Models fill an important role in this context by facilitating extrapolation/interpolation and synthesis of available knowledge
- A local water manager does not have the "umbrella" perspective to prioritize between measures, especially not with regard to their impact on several environmental goals – the integrating capability of models can facilitate
- More resources are needed for operational, continu-

ous use of models. There is a need to shift from project based to continuous use of models.

- There is a need for coordinating efforts in order to ensure continuous use of models in water management. The Swedish Agency for Marine and Water Management (HaV) can play a central role to obtain this by the creation of a central platform with information on modelling related actives in Swedish water management.
- There is a need for further development of robust, user-friendly modelling tools that can be used by others than modellers. Transparency and communication aspects are critical – the user should have access to information about data and used assumptions.
- Ranges of uncertainties should be given – especially when results are to be used for classification of water bodies or for testing of if environmental goals are obtained by different combinations of measures.
- There is a need for clearer links between modelling of surface and groundwater, e.g. linked to planning of measures that might have an impact also on groundwater. Also lake models need further improvement.
- The local perspective is important. In most cases it is local stakeholders that have to implement remedies.
- Communication of model results need to be different depending on if it is to facilitate knowledge transfer between modellers and e.g. county boards or between authorities and local stakeholders.
- Models are not providing"the truth", but a good estimate from available knowledge and data – their strength is mainly as its ability to act as a tool in discussions between various actors.
- If models are to be used in permit processes, this should be done by independent authority that runs the models, with high transparency in the modelling process as well as a high degree of participation by operators seeking permits.
- Promote "success stories" where models have been used for collaboration between stakeholders and authorities and where this work has resulted in implementation of measures. By doing this, the possibility that politicians will invest more resources in the use of models in water management will increase.

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Notes

[1] http://www.smhi.se/svenskaihp/aktiviteter/workshop-om-att-anvanda-modeller-i-vattenforvaltning-1.17992
[2] http://ec.europa.eu/environment/water/water-framework/
[3] http://ec.europa.eu/environment/water/water-bathing/
[4] http://ec.europa.eu/environment/water/flood_risk/
[5] http://ec.europa.eu/environment/water/water-drink/legislation_en.html
[6] http://ec.europa.eu/environment/water/water-urbanwaste/
[7] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0672:FIN:EN:PDF
[8] http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm
[9] http://ec.europa.eu/environment/water/water-framework/info/timetable_en.htm

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